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Deterioration in Water Quality of River Kshipra At Ramghat, During Mass Bath, Ujjain, M.P. India

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Abstract

People from all across the world come to take dip in holy river Kshipra, by doing so they think that they will set themselves free from all their sins but they do not know that they are exposing them self to several health problems and various dangerous diseases. Ujjain is one of the ancient and holy city of India situated on the banks of river Kshipra. Khipra river is known for its sacracy and hence, enjoys status of mother goddess in mythology. Performance of various anthropogenic activities at the banks of the river leads to depletion of water quality. This induces a vast change in the river ecology and upsets the aquatic flora and fauna. Keeping this in view, the present study was conducted to evaluate the effect of mass bathing on water quality in terms of physicochemical and microbiological parameters before, during and after mass bath. In the present study higher values of biological oxygen demand (BOD) and Chemical oxygen demand (Cod) were observed indicating higher degree of organic pollution rendering water to be unsuitable for drinking and bathing purposes. DO was found to be low and within a range of 3.3-6.0 mg/litre which declined during and after mass bath certifying the increased pollution load on the water body. Microbial parameters like faecal and total coliform were found to be high during and after mass bath. Several cases of water born diseases like typhoid, skin, eye, ear and urinary tract infections were reported from local and near by city hospitals immediately after mass bath especially in summer. Further, water quality of Kshipra river was assessed on the basis of water quality index, according to which water was reported to be of very bad status. As per CPCB norms water was found to be of D class and was not fit for drinking, bathing and domestic use without proper treatment.

Keywords : Water Quality, Pollution, Physicochemical, Microorganisms, Kshipra River, Mass Bath.

Introduction

According to Hindu mythology, Ujjain is one of the holiest places and is one of the biggest mass bath centre of the entire country. The holy city of Ujjain is site to some of the most sacred Hindu rituals and one can see pilgrims and devotees across the globe at Ujjain to offer prayers on auspicious occasions by having a dip in the sacred Kshipra. It is not possible for city municipality to make proper arrangements for lodging and other civic facilities for millions of pilgrims during festive occasions. Human interactions and interventions are the key factors influencing water quality of any aquatic system especially in case of a sacred river where addition of pollutants from various sources ruins the river ecosystem which is an integral part of the city.

Mass Bathing, an old age ritual in India is one of the main cause for increasing organic pollution of the river. High amount of organic matter is flooded in the river in form of soaps, detergents and washing of cloths. Ujjain city is situated on the banks of river Kshipra, which is a big pilgrim centre firstly, due the presence of Mahakaleshwar Temple and secondly, due to the occurrence of Mahakumbh mela. Mass bathing on Mahakumbh, Solar Eclipse, Makar Sankranti, Shivratri, Kartik Pornima (full moon), Somvati Amavasya (1stof moon day falling on Monday), Sanivari Amavasya (1st of moon day falling on Saturday) and Panchkoshi yatra are considered to be very important. Millions of pilgrims take bath in this holy river on such occasions. However, mass bath deteriorates water quality of the river to a great extent. This intense water quality deterioration can lead to several diseases like cholera, typhoid, skin diseases, and many more

that affect human body. The aim of the present study is not to draw a picture of horror and discourage religious activities but the study will provide a base line data on physico-chemical and microbiological aspects to maintain integrity and secrecy of the river in order to control water-born diseases and hence improve water quality in order to conserve this holy river.

Materials and Methods

Study Area

River Kshipra originates from a hill of Vindhya range, one mile south of Kshipra village lying 12 km south-east of Indore city (M.P.). In the present study, Ramghat was the selected study site, its distance from origin is 65.4km. The site is marked by presence small temples, akharas and high anthropogenic activities like flower, ashes and coconut dumping. It is one of the chief mass bath centre of Ujjain city.

Water Sampling

Three major mass baths covering all three seasons viz. summer, winter and monsoon were analyzed. First mass bath was on 30th April (Panchkoshi yatra), second on 25th August (Somvati Amavasya) and third on 5thNovember (Kartik Purnima).

Samples were collected one day prior to mass bath, on the occasion of mass bath, and after mass bath continuously for 10 days. For analyses of physicochemical parameters, samples were collected in 2lit. sterile bottles and bacterial samples were collected aseptically using 500 *ml* sterile bottles which were kept in ice bucket, they were then transported to the base laboratory within 24 hours.

Isolation and Identification of Total and Faecal coliform

The microbiological parameters like total coliform, faecal coliform were isolated by using methods of APHA, (2005). These samples were diluted to 10^3 and were subjected to membrane filtration technique, after filtration membranes were placed on different media which were then incubated at 37ºC for 24 hours. MaConkey Agar and Briliant Green media were used for obtaining faecal and total coliform count.

Analysis of Physicochemical Parameters

Sampling and analysis of various physicochemical parameters were done by using standard methods given in APHA (2005). Water Quality Index was calculated according to Mr. Brain Orams WQI Index, consumer support group online calculator (Oram,2007).

Water Born Diseases

Data of water born diseases was obtained by survey from major hospitals of Ujjain and Dewas city. A structural interview involving about 500 households, who took dip in the river randomly selected from all the four quarters in the city of Ujjain and Dewas. Respondents were required to furnish information on how many people of their family and friends took baths and what all health problems were experienced by them after baths. Pilgrims were interviewed by conduction of surveys in guest houses, near by hotels and dharamshalas on the mass bath day.

Results and Discussion

The present study was conducted in river Kshipra at Ramghat study site to evaluate the effect of mass bathing on water quality of the river. The mass holy dip by millions of devotees in the river tends to disturb river ecology which leads to marked variations in different physicochemical and microbiological parameters. Three important mass baths covering all three seasons viz. summer, winter and monsoon at Ramghat study site of Kshipra river were analysed and the values were compared to pre and post bath period, results obtained clearly reveal deterioration of water quality during and after mass baths which stabilize after a long period of time. The mass baths were also found to contribute in disturbing health status of pilgrims taking bath in the river.

Impact of mass baths on Physicochemical Parameters

Air and water temperature showed seasonal variations. Air temperature was found within range of 15.2^0C-42.1^0C. Similarly, water temperature ranged from 15.8^0C-32.2^0C. Minimum values were found in the month of November and maximum in the month of April.Temperature is important parameter as it directly affects aquatic life and reduces the Dissolved Oxygen (D.O.) concentration in water making oxygen less available for respiration (Jalal and Sanalkumar 2012). In the present study pH was observed within a range of 8.0-8.8 which showed Slightly alkaline nature throughout the study period, indicating that water are well buffered and in high tropic status. The pH values increased during and after mass bathing period. The pH levels were within limits, set for protection of aquatic life that is 6.5-9.0 (USEPA, 1975), irrigation 5.5 to 9.0 and domestic use 7.0-9.9 (ICMR, 1975).

The dissolved oxygen content of water in Kshipra river during mass bath ranged from 3.3-4.4 mg/lit. in April, 3.3-5.6 mg/lit in July and 4.1-6.0mg/lit. in November. It was observed that DO concentration decreased during dip and after dip period which recovered after a long period of time. Decrease in DO content during and after mass bath may be due to entry of organic, domestic and biodegradable wastes by pilgrims and their microbial decomposition that utilize oxygen and release carbon dioxide in turn. Decrease DO level after mass bathing was observed by Bhatnagar and Sangwan (2008) in Brahmsarovar, Haryana. Most of the times DO content of water at Ramghat was found to be below suitable range as it is the site with highest human interventions. Dissolved oxygen is one of the most important factors of aquatic life and most species become stressed when DO levels drops to 4-2 mg/lit. Values were less during mass bath in March because higher temperature was observed during this period which enhances more consumption of oxygen in water consequently affecting BOD. Comparatively lower DO was observed during and after dip than before dip, the values however stabilized and returned back to normal status after a long period. However, in Kshipra

river DO concentration is below the permissible limits during and after mass bath periods indicating high pollution load in the river.

Hardness during mass bath period ranged between 418-532mg/litre in April, 506-624 in August and 428-524 mg/litre in November. Higher values of hardness were obtained after dip in comparison to during and pre dip periods, this was due to the extensive use of soaps and other materials by bathers. Higher values of hardness were observed during mass bath in summer, followed by mass bath in monsoon and lowest was observed during winter mass bath. The increased hardness and Calcium levels in the water of the river after the festival may be attributed to the addition of high quantity of bleaching powder and lime added to the sediments during the preparation of the river for the holy bath as Kshipra is river with less flow preparation of the river for mass baths by lime addition is a common act. Total alkalinity ranged between 308-336 mg/lit. in April, 314-375 mg/lit. in July and 256-334mg/lit. in November. Chlorides of Kshipra river during mass baths ranged between 145.85-173.15mg/litre in April, 159.84-202.40mg/lit. in August and 110-163mg/lit. in November. Calcium ranged between 88.17-96.24 mg/lit in April, 314-377mg/lit. in August and 256-340mg/lit. in November (Table 1 A,B,C). High values of total alkalinity, calcium and chloride were observed after mass bath and lower before mass bath which is due to high organic matter and pollution due to animal origin like, adding ashes and urination in water which increases the chloride content of water. Chloride showed positive correlation with hardness, BOD and COD while negative correlation with DO and transparency. Correlation between chloride and hardness may be attributed to the presence of chlorides of sodium, calcium and magnesium which contribute to total hardness. Hence, increased chlorides are responsible for increase of total solids and hardness after mass bathing. Similar trends were recorded by Sharma *et al.* (2012) during mass bath in Ganga river.

Biological oxygen's demand gives an idea of quantity of biodegradable organic substance present in water, which is subjected to aerobic decomposition of microorganism. Thus providing a clear state of pollution, in this study BOD after dip was found to high then during and before dip. The trends of fluctuation in BOD values showed maximum in monsoon followed by summer and minimum during winter mass baths respectively. It was found within a range of 26.6- 56.1 mg/litre. However BOD samples above 5mg/litre are considered to be bad, which shows contamination of water by various biological, organic and inorganic pollutants as reported by Dhanapakiam *et al.*(1999). Pandey and Sundaram (2002) pointed out that higher BOD is also attributed to the performance of worship rituals by bathers. BOD in river Kshipra was found to be higher than permissible limits of throughout the study period. Chemical Oxygen Demand (Cod) is the measure of oxygen required for chemical oxidation. Its values are generally higher than BOD when organic matter contains large amount of biologically resistant substance. During this investigation COD ranged between 96.4-209.4 mg/litre throughout higher during and after dip. Results of the present investigation draw support from findings of Chaturvedi *et al.* (2003) higher COD might be due to the presence of huge amount of accumulated organic matter and its incomplete oxidation. The permissible limits for COD is 10 mg/l for drinking water and the values obtained was found to be much higher than the prescribed values. Transparency and turbidity are other important parameters related with penetration of light. In this study transparency was found within the range 29-61cm. Low values of transparency were observed during and after dip. Turbidity ranged between 25-78 NTU. Higher turbidity was found to be associated with high microbial growth, dissolved solids and higher contents of nutrients etc. Higher turbidity was evident during monsoon mass baths i.e. in August due to high total coliform count (Table-1 A,B,C).

Impact of Mass Bath on Microbial Count

The biological character sticks of water and wastewater are of fundamental importance to human health, in controlling diseases caused by pathogenic microbes of human origin and because of the role they played in decomposition of waste. Faecal indicator bacteria like total coliform, faecal coliform, *E. coli* and faecal *Streptococcus* are excreted by humans and warm blooded animals. Faecal *E. coli* and faecal *Streptococcus* are most widely used indicator bacteria of pollution. Faecal coliform is found within a range of 282-385X10^3CFU/100 ml in April, 290-402 X10^3 CFU/100 ml in August and 216-350X10^3 CFU/100 in November. Total coliform ranged between 590-684X10^3 CFU/100 in April, 622-742X10^3 CFU/100 in August and 426-575X10^3 CFU/100 in November (Table-1 A,B,C). Higher values of these microbial indicator organisms were found during and after dip, which indicate that river gets polluted during mass baths. The high coliform count obtained in the samples may be indicator of the fact that water is flooded with faecal contaminant. Similar findings of high microbial count during and after dip are supported by Kulshrestra and Sharma (2006) in Ganga river Uttaranchal, Jalal and Kumar (2013) in Pambha river Kerela, Jalal and Sanalkumar (2012) in Archeneovil river Kerala and Chourasia and Raj Karan in Mandakini river M.P. (2015). Mass bathing an old Indian ritual which is a constant source of contamination of water bodies. It is the biggest culprit for increasing the number of coliform in water. High faecal coliform count indicates the presence of various pathogenic bacteria like *Salmonella, Pseudomonas, Shigella, Mycobacterium* etc. The presence of *Pseudomonas* species is registered at Triveni study site and is reported to increase during mass baths (Bhasin *et al.*2015).

Impact of Mass Bath on Water Quality Index

WQI ranged from 20-24 during mass bath in November, 16 -19 in August and 18-22 in April which

indicates heavy pollution throughout the study period. According to Mr. Brain Oram online calculator water quality index legend range between 90-100 indicates excellent water quality, 70-90 indicates good water quality, 60-70 indicates medium water quality, 25-50 refers bad water quality and 0-25 certifies very bad water quality (Oram, 2007). However, water quality of Ramghat is found to be very bad as per water quality index throughout the year but, it is known to deteriorate more during and after mass baths. Sharma *et al.*(2014) recorded WQI values 32-42 in Hindon river U.P. and categorized all locations of Hindon river to have bad water quality. The study indicates positive correlation between temperature, turbidity, total alkalinity, total hardness, BOD, COD, FC and TC whereas DO and transparency showed negative correlation with pH, total hardness, BOD, COD, FC and TC. Similar findings were reported by Bhor *et al.* (2013) in Godavari river Maharastra and stated that continuously pollution of water sources by human activities may lead to some health problems to humans. One of the biggest source of water contamination and depletion of water quality of our holy rivers are mass baths which leads to increased nutrient concentration, organic and inorganic substances in the water body along with different pathogenic microorganisms, which remains constant for a longer period of time. Mass bath serve as a hazard for water quality because when million of pilgrims enter in Kshipra or any other river ecosystem the settled silt, clay and sand mixes with the surface water which enhances total hardness, calcium, chloride, total alkalinity, and other metals present in the soil of the river. Increased values of all physicochemical and microbiological parameters were observed during and after mass baths which returned to normal position after a long period due to self purification capacity of river. Mass bath is disrupting the ecology of river Kshipra from a very long time. The Ujjain city hosts Mahakumbh (mass bath) which greatly influences river ecosystem of Ujjain city especially at Ramghat. In Mahakumbh of 1992 a major drop in DO values from 8.1 mg/ litre to 1.07 mg/litre were observed *(*Rao *et al.1992).* The massive mass bath had its influence on the water quality of the particular site for about an year. The accumulation of soap films, hair, dead skin, body oil, dirt and faeces in the river create ideal conditions for bacterial survival and multiplication.

Impact of Mass Bath on Human Health

The organic matter contribution during mass bath is normally significant and is the main cause for giving rise to various epidemics after mass baths. Presence of faecal and total coliform indicates the presence of pathogenic bacteria which has been reported in high number at various sites of Kshipra river (Bhasin *et al*.2015). Such harmful bacteria are known to give rise to many diseases. An increased count in case of typhoid fever (3-5%) has been reported, many cases of gastrointestinal infections (12-15%), eye and ear problems are reported from hospitals of the city particularly after summer mass baths. Cases of Salmonellaeses (13-17%) are also reported due to ingestion of river water (Achman). Urinary tract and skin infections (20-23%) are found to occur frequently in people taking bath in the river. However, this data does not correspond with the exact number of sufferers as their would be more people suffering from disorders after mass baths as many devotees went back home and could not be contacted.

Mode of Pollution in Indian Rivers

Ramghat is one of the most polluted site of Kshipra river. Presence of brick making activity is observed between Triveni and Ramghat about 100 brick kilns have damaged the flood plains. These pollutants are found to enter the river during monsoon season and contribute to the increased pollution at Ramghat as a result of which increased values of different parameters are observed in the mass bath of August. In developing countries, the main source of river pollution is mainly via faecal contamination, discharge of untreated waste and sewage in the water body, lack of proper sanitation facilities and agricultural run off. In developed countries, industrial effluents, agricultural runoff and mixing of pesticides and fertilizes with the river or tap water contributes as a major source of water contamination. In such industrialised countries, the success of applied control strategies is confirmed by small number of water-born outbreak caused by various water born microbes. In a resource constrained country like India, surface water is used for drinking, bathing, recreational and holy activities. However, factors like sewage and waste discharge, industrial effluents, agricultural runoff contribute to increase the level of pollution in Indian river, but another factor which is a very important reason for pollution of Indian river system is the occurrence of religious festivals conducted on the banks of major Indian holy rivers like Ganga, Yamuna, Godavari, Kshipra etc. The river water gets flooded with many worship rituals and this water if used without proper treatment can lead to various health hazards. River Kshipra hosts the Mahakumbh mela which is a religious festival organized in every twelve years attracting millions of tourists and devotees from all around the world to take bath in this sacred river, this gives rise to massive mass baths further depleting water quality. Apart from washing with detergents, piligrims offer milk, curd ghee, flowers, coins, ashes and other religious material in water. This material is brought in polythene bags which are dumped by the devotees in the river. These are non-biodegradable so they disturb the aquatic flora and fauna. River Khipra enjoys status of Goddess in Hindu mythology so dumping of body ashes and statues of Lord Ganesha is Lordess Durga etc.an evident act observed at the banks of this river. These activities certify that in holy rivers of India mode and nature of pollution is different from water bodies across the world. However, CPCB (1982) recommended that total coliform should be less than 500 in bathing water. DO of 5mg/lit. or more and BOD 3mg/lit. or less. The water of Khipra river

does not fit in the above mentioned criteria and is found to be in D class of water with respect to CPCB classification criteria.

Conclusion

Due, to increased pollution levels river water is found to be in highly stressed conditions. The study would help in water quality monitoring and management in order to improve the quality of water with minimum sustaining management. Results indicate that water of river Kshipra is highly polluted from the point of view of physico-chemical and microbial parameters. Water quality index also indicates deterioration of water quality especially during and after mass bath. On the basis of physico-chemical and microbiological analysis it can be stated that the quality of river water deteriorates with the number of pilgrims taking dip. On the basis of present findings it was concluded that mass bathing altered water quality of Kshipra river and water of the river is found to be of D class according to CPCB norms. Anthropogenic activities like, dumping of flowers and performance of worship rituals by the bathers increases the organic pollution at Ramghat study site. Local authorities should come forward and should take few steps in this direction to improve water quality and provide lifeline to this holy river.

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Table-1A: Physico-Chemical, Microbiological Parameters and Water Quality Index During Mass Bathing in April At Ramghat Study Site of Kshipra River

S.No.	Parameters	Pre Dip	During Dip	After Dip									
1.	Date	28th Apr. 2014	29th Apr. 2014	30th Apr. 2014	1st May 2014	2nd May 2014	3ed May 2014	4th May 2014	5th May 2014	6th May 2014	7th May 2014	3nd Apr. 2014	4th Sep. 2014
2.	Number of pilgrims who took bath and occasion	1,75,000 (approximately) took bath on occasion of Panchkoshi yatra											
3.	Atmospheric Temperature (ºC)	35.8	38.1	38.2	39.0	42.1	40.4	40.4	39	38	38.2	38.4	38.0
4.	Water Temperature(ºC)	26.3	24.2	29.3	25.4	25.3	28.4	29.2	27.3	26.4	25.9	25.3	25.1
5.	Transparency (cm)	43.0	32	30	34	34	35	37	38	39	39.1	34	41
6.	Turbidity (NTU)	34	45	49	47	43	41	40	39	38	37	35	34
7.	pH	8.2	8.4	8.6	8.5	8.4	8.4	8.2	8.2	8.3	8.3	8.2	8.2
8.	Carbonate (mg/l)	15	18	18	18	17	18	18	17	17	16	15	15
9.	Bicarbonate (mg/l)	293	315	320	318	310	311	309	306	302	300	329	325
10.	Total Alkalinity (mg/l)	308	333	338	336	327	329	327	323	324	316	314	312
11.	Chloride (mg/l)	145.85	162.48	173.15	170.15	162.14	156.7	154.3	153.2	152.1	151.1	149.2	148.2
12.	Calcium (mg/l)	88.17	93.48	95.12	96.24	91.86	90.4	90.2	90.1	90.0	89.5	89.0	89.0
13.	Total Hardness (mg/l)	418	525	532	530	528	502	500	490	486	460	430	424
14.	Dissolved Oxygen (mg/l)	4.4	3.4	3.3	3.4	3.5	3.6	3.7	3.8	3.8	3.9	4.0	4.2
15.	Biological Oxygen Demand (mg/l)	37.2	49.2	52.4	51.2	50.1	45.2	43.3	42.8	41.7	41.0	40.0	40.0
16.	Chemical Oxygen Demand (mg/l)	148.2	201.21	209.42	204.3	200.2	195.4	189.1	179.1	169.1	158.3	151.2	150.1
17.	Faecal Coliform (X 10^3 FU/100ml)	282	370	385	360	352	332	314	308	300	298	290	285
18.	Total Coliform (X 10^3 CFU/100ml)	590	680	684	681	662	654	642	640	620	610	606	598
19.	Water Quality Index	22	20	18	19	19	20	21	21	21	22	22	22

Table-1B: Physico-Chemical Microbiological Parameters and Water Quality Index During Mass Bathing in August At Ramghat Study Site of Kshipra River

S.No.	Parameters	Pre Dip	During Dip	After Dip									
1.	Date	24th Aug. 2014	25th Aug. 2014	26th Aug. 2014	27th Aug. 2014	28th Aug. 2014	29th Aug. 2014	30th Aug. 2014	31th Aug. 2014	1st Sep. 2014	2nd Sep. 2014	3ed Sep. 2014	4th Sep. 2014
2.	Number of pilgrims who took bath and occasion	2,00,000 (approximately) took bath on the occasion of Somvati Amavasya (1st day of full moon falling on Monday											
3.	Atmospheric Temperature (ºC)	36	35	34	36.2	37	37.2	36.8	34.9	35.2	36.1	36.8	37
4.	Water Temperature (ºC)	26.2	32.2	32.1	34.5	33	33.2	31.4	30.8	31.5	32.8	32.0	31.8
5.	Transparency (cm)	37.5	29	26	28	29	32	31	31	33	32	34	35
6.	Turbidity (NTU)	39	72	78	69	64	63	59	57	53	49	45	40
7.	pH	8.7	8.8	8.6	8.5	8.3	8.4	8.4	8.4	8.5	8.5	8.5	8.5
8.	Carbonate (mg/l)	24	32	35	35	34	31	30	28	29	27	25	25

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9.	Bicarbonate (mg/l)	290	320	340	342	330	318	310	308	301	297	295	295
10.	Total Alkalinity (mg/l)	314	352	375	377	364	39	340	328	330	324	320	320
11.	Chloride (mg/l)	159.84	200.4	202.4	200.8	194.6	184.7	179.6	175.4	170.8	166.2	160.5	160.5
12.	Calcium (mg/l)	86.5	99.4	102.5	101.4	100.3	99.4	98.5	94.6	93.2	92.5	91.6	90.7
13.	Total Hardness (mg/l)	506	617	624	621	600	595	585	573	560	549	535	520
14.	Dissolved Oxygen (mg/l)	5.6	3.9	3.4	3.3	3.5	3.8	3.8	3.9	3.7	4.0	4.0	4.2
15.	Biological Oxygen Demand (mg/l)	38.4	52.2	56.8	56.1	52.1	48.8	44.2	44.1	43.0	42.0	41.0	41.0
16.	Chemical Oxygen Demand (mg/l)	138.8	202.2	208.1	208.1	206.2	196.3	191.4	186.5	184.2	179..8	171.2	164.6
17.	Faecal Coliform (X 10^3 CFU/100ml)	290	396	402	401	393	384	362	356	342	331	321	309
18.	Total Coliform (X 10^3 CFU/100ml)	622	735	742	740	729	708	693	680	672	661	652	641
19.	Water Quality Index (Oram 2007)	19	16	17	18	18	18	18	19	19	19	19	19

Table-1C: Physico-Chemical, Microbiological Parameters and Water Quality Index During Mass Bathing in November At Ramghat Study Site of Kshipra River

S.No.	Parameters	Pre Dip	During Dip	After Dip									
1.	Date	4th Nov. 2014.	5th Nov. 2014.	6th Nov. 2014.	7th Nov. 2014.	8th Nov. 2014.	9th Nov. 2014.	10th Nov. 2014.	11th Nov. 2014.	12th Nov. 2014.	13th Nov. 2014.	14th Nov. 2014.	15th Nov. 2014.
2.	Number of pilgrims who took bath and occasion	2,50,000 (approximately) took bath on the occasion of Kartik Pornima											
3.	Atmospheric Temperature (ºC)	18.0	19.0	18.3	17.2	16.8	17.5	18.2	16.6	15.2	16.8	17.0	16.3
4.	Water Temperature (ºC)	17.0	18.1	18.3	16.4	17.2	16.9	16.3	16.4	15.8	16.3	16.5	16.0
5.	Transparency (cm)	61.1	32.0	33.2	35.3	37.6	43.2	46.2	48.2	53.4	59.5	60.4	60.3
6.	Turbidity (NTU)	25	40	40	38	33	31	30	28	28	27	26	26
7.	pH	8.2	8.3	8.3	8.1	8.2	8.0	8.2	8.2	8.2	8.1	8.0	8.0
8.	Carbonate (mg/l)	14	26	30	29	26	24	22	20	20	20	19	17
9.	Bicarbonate (mg/l)	242	300	310	305	302	294	284	278	272	269	259	252
10.	Total Alkalinity (mg/l)	256	326	340	334	328	318	306	298	292	289	278	269
11.	Chloride (mg/l)	110.88	162.98	163.8	160.92	154.6	152.6	149.6	141.6	134.6	128.5	120.6	115.4
12.	Calcium (mg/l)	74.54	101.4	105.6	107.8	104.2	100.09	96.21	90.14	83.48	80.16	79.26	75.84
13.	Total Hardness (mg/l)	394	510	519	524	522	515	502	495	478	459	439	428
14.	Dissolved Oxygen (mg/l)	6.0	4.3	4.1	4.2	4.5	4.8	5.0	5.3	5.5	5.8	5.9	6.0
15.	Biological Oxygen Demand (mg/l)	26..6	40.1	41.0	41.0	41.0	40.1	39.2	38.2	36.2	35.1	33.9	32.3
16.	Chemical Oxygen Demand (mg/l)	96.4	165.4	168.5	162.4	158.6	146.4	135.2	131.4	124.8	121.8	116.2	110.8
17.	Faecal Coliform (X 10^3 CFU/100ml)	216	326	332	350	343	319	300	289	269	249	239	228
18.	Total Coliform (X 10^3 CFU/100ml)	426	572	575	568	564	549	523	500	480	472	452	430
19.	Water Quality Index	24	20	20	21	22	23	23	23	23	24	24	24